

# Multipacting calculations and measurements on coupler tests

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# Contents

1. General notes
2. Calculations
3. Experimental results
4. Summary

# 1. General notes

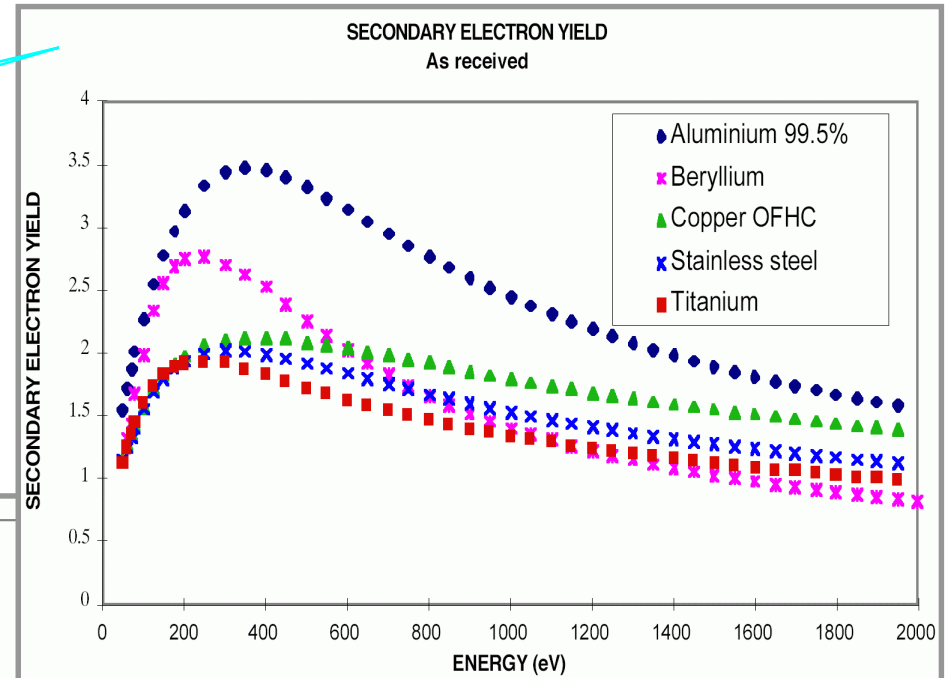
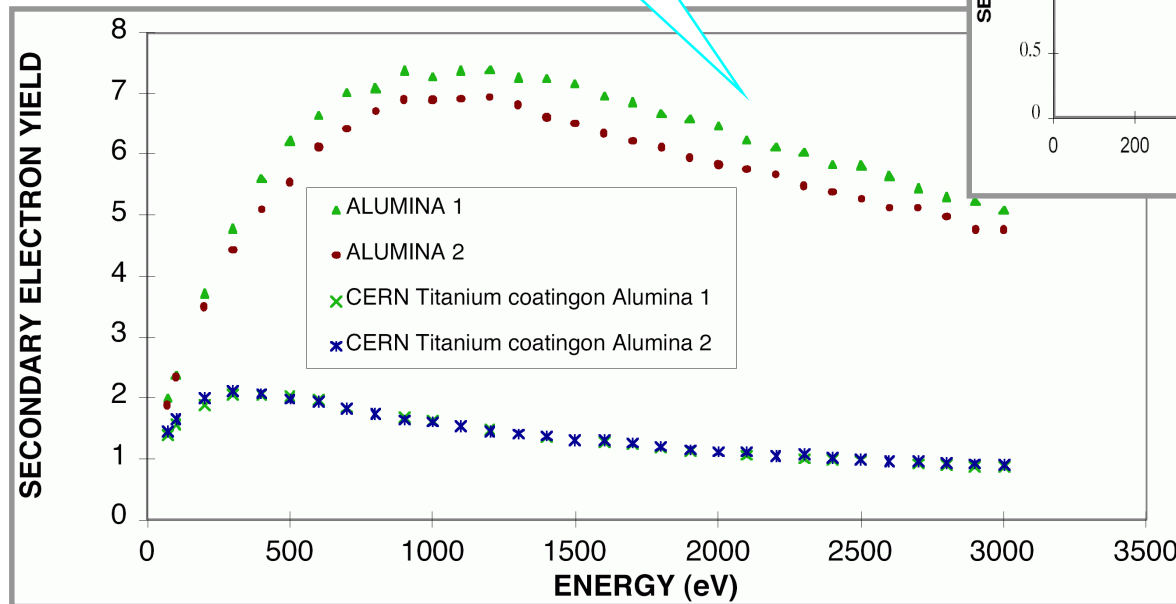
## Multipacting:

- Resonant RF electron discharge in vacuum.
- Electron trajectories: 1 point or 2 points.
- Determined by RF field and geometry.
- Order of multipacting: electron travel time in RF periods, lower order is more stable – more dangerous.
- Secondary Emission Coefficient  $> 1$  (pure Cu – 1.2,  $\text{Al}_2\text{O}_3$  – 6), SEC depends on the surface and impact energy.
- Scaling: Resonant RF Power  $\sim (\text{frequency} \times \text{dimension})^4$  (coax).
- Multipacting creates electron avalanche, which can desorb gas from metal surface (also crysorbed gas).
- DC bias can influence the multipacting.

# Secondary Emission Coefficients

metals

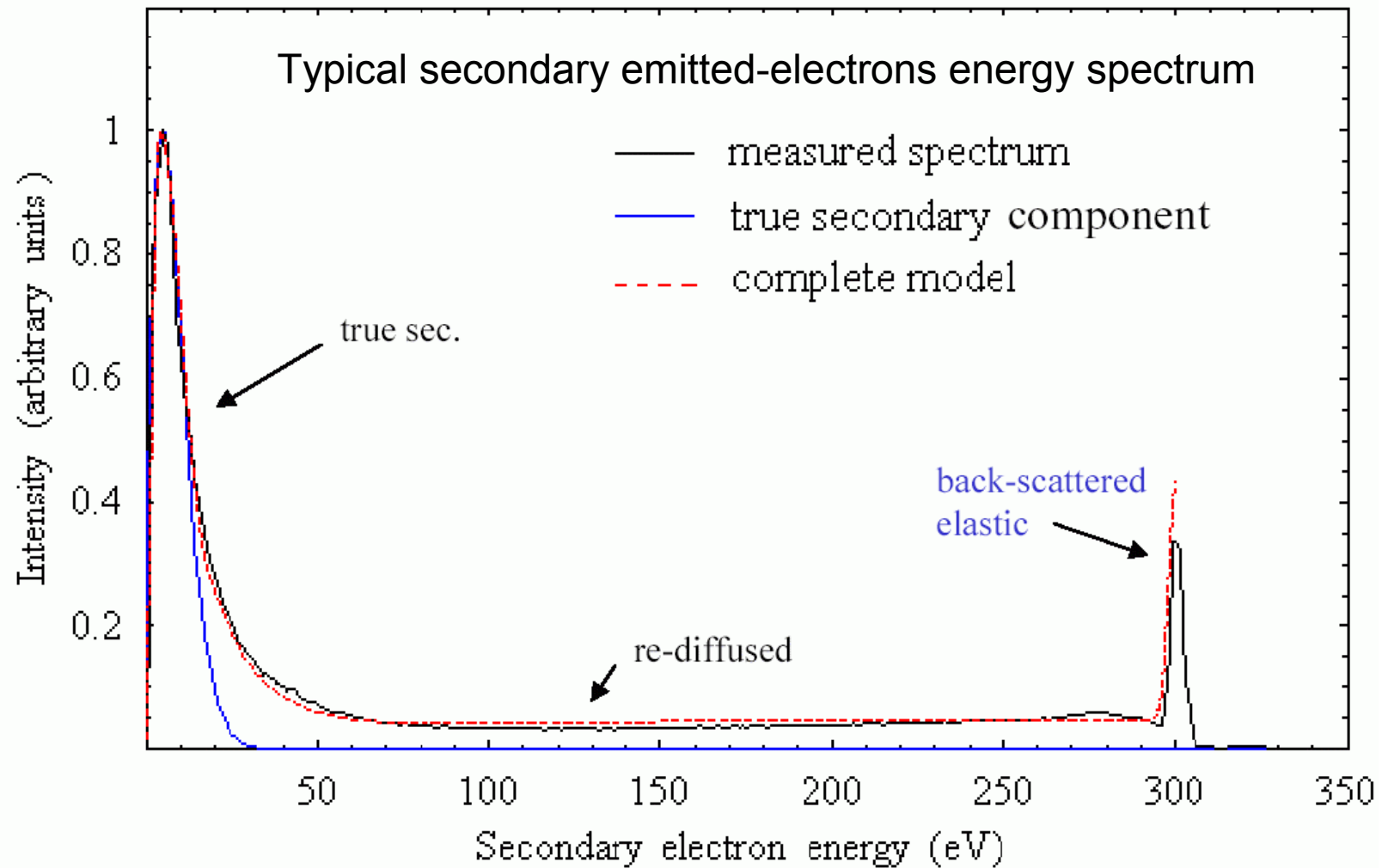
ceramics ( $\text{Al}_2\text{O}_3$ )



from N. Hilleret, CERN - LHC/VAC

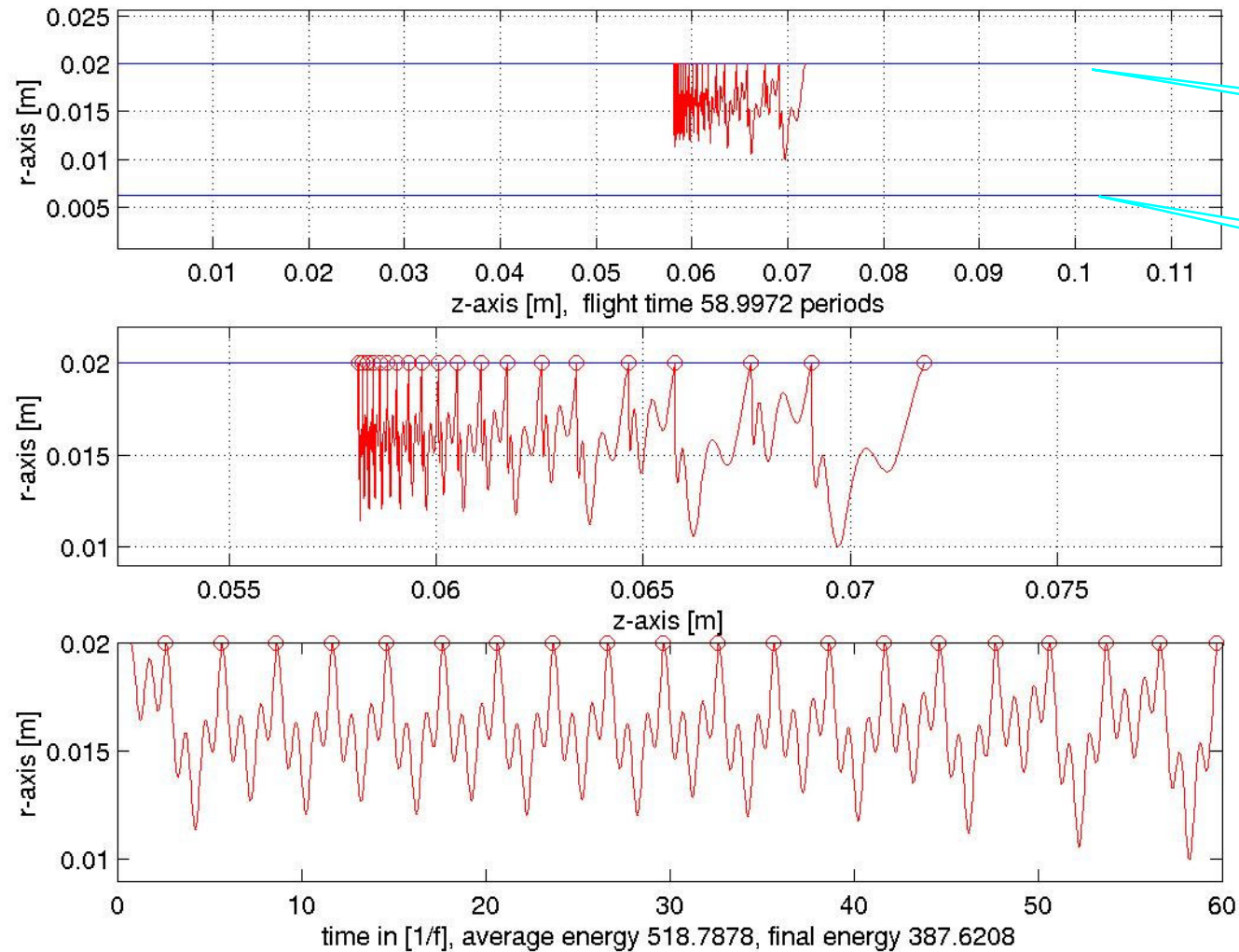
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# Secondary Emission Spectrum



## 2. Calculations: MultiPac (1)

MultiPac 2.1 Electron Trajectory, N = 20, 22-Jan-2003



Outer coax conductor

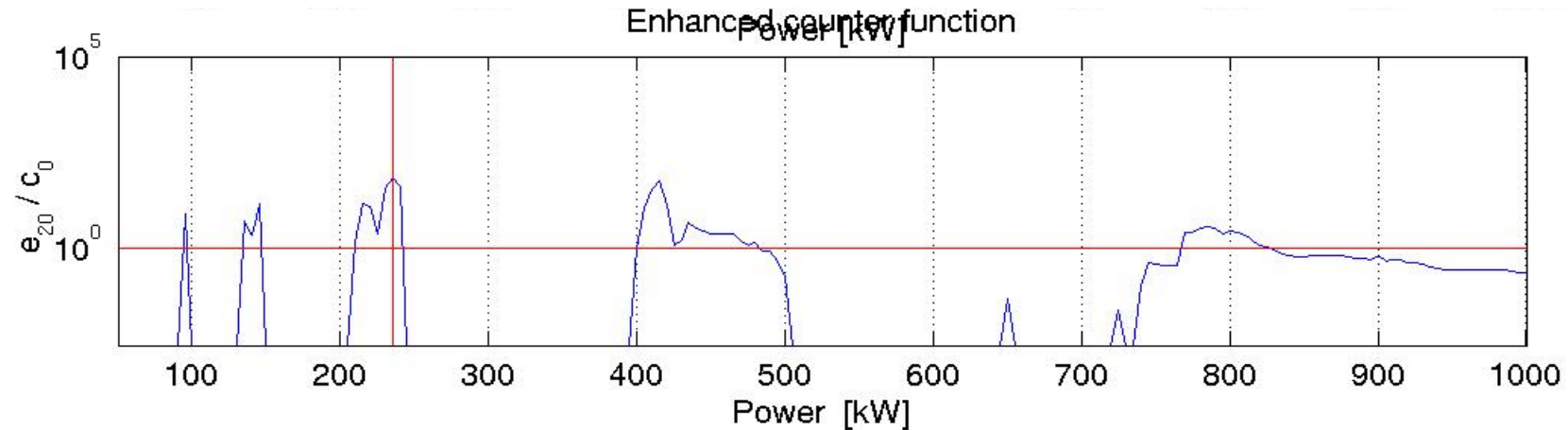
Inner coax conductor

MP:  
1 point  
3rd order

RF power 230kW

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# MultiPac (2)



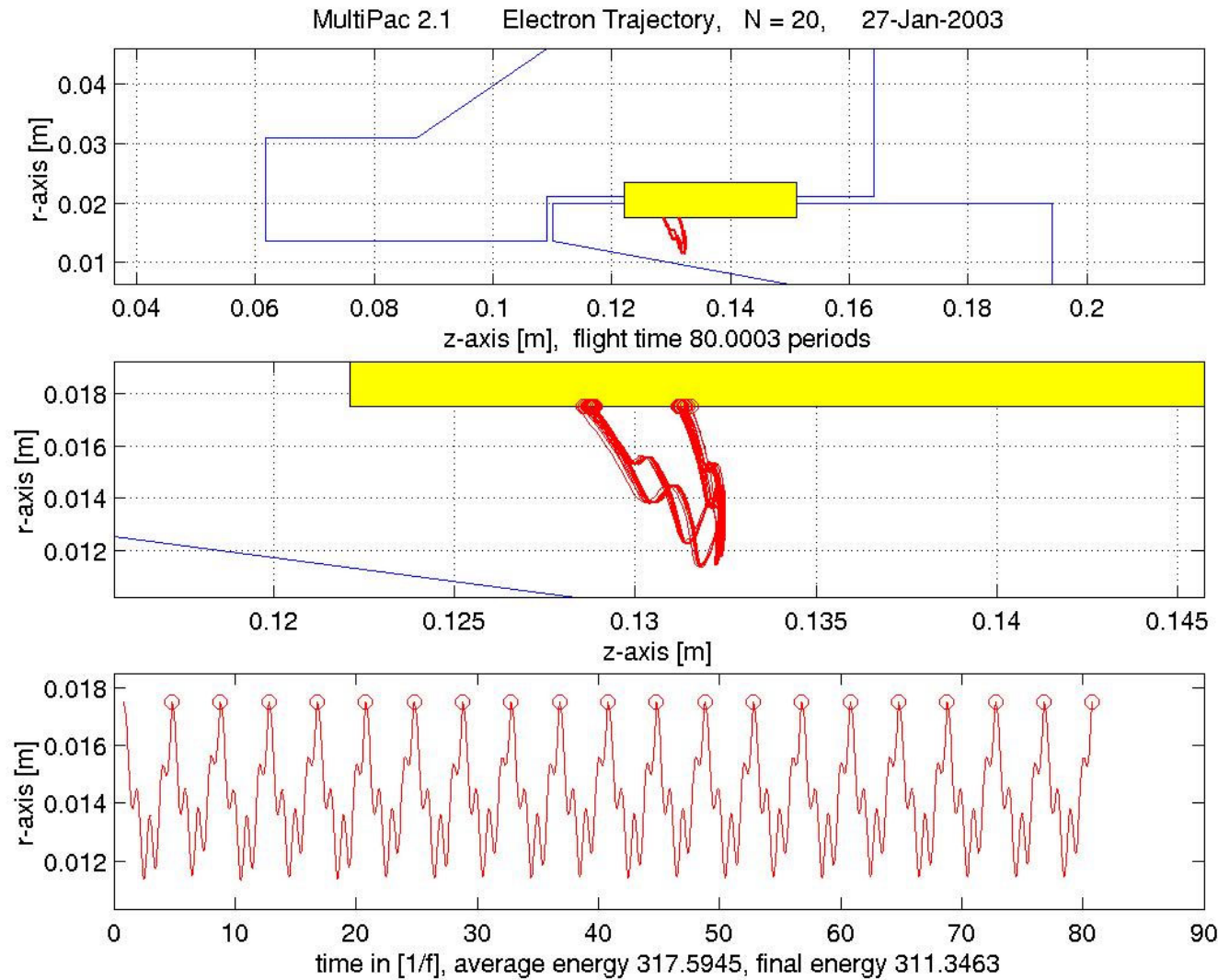
TTF III coupler cold part coax:

Geometry: coaxial line 12.5mm/40mm,  $L=\lambda/2=115.3\text{mm}$

Resonant levels:

95kW, 135-150kW, 210-245kW, 400-480kW and 780-815kW

# MultiPac (3)



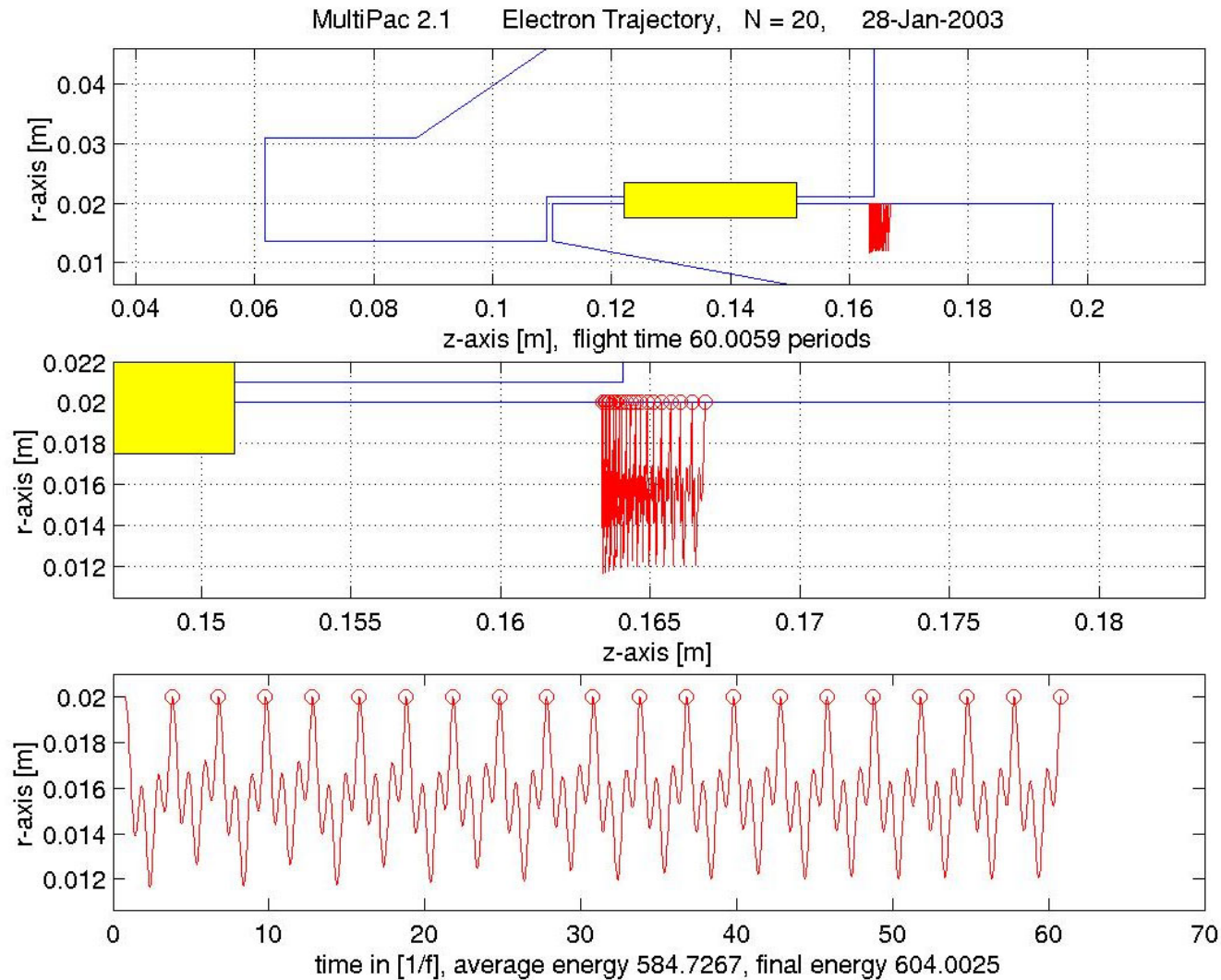
TTF III  
coupler  
cold window

MP:  
1 point  
4rd order

RF power 920kW

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# MultiPac (4)



TTF III  
coupler  
cold window

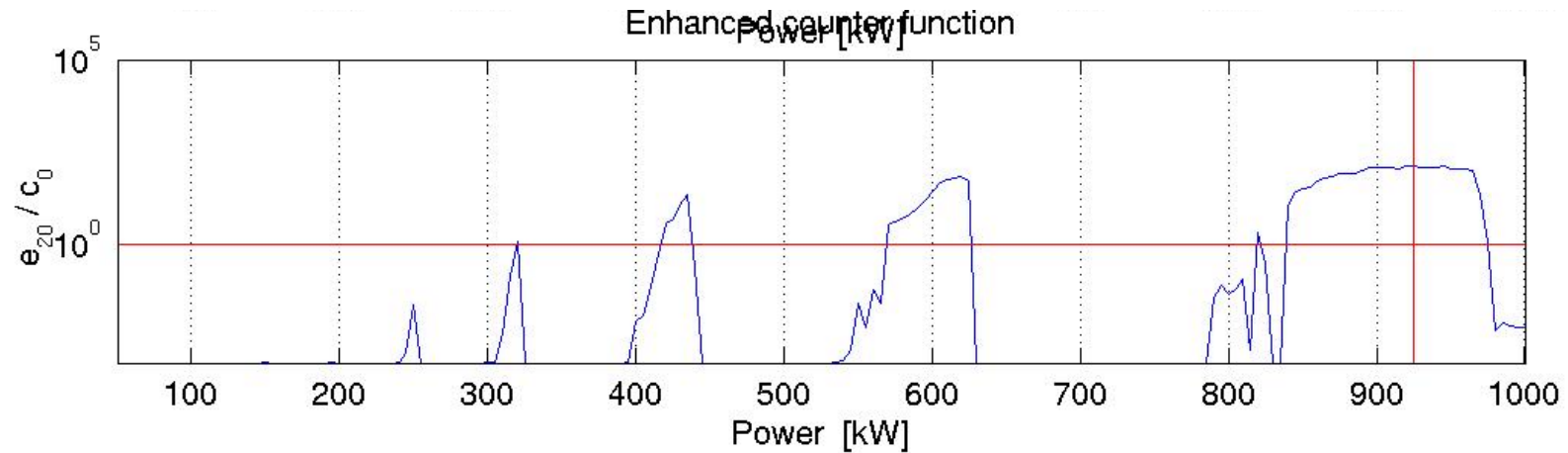
MP:  
1 point  
3rd order

RF power 470kW

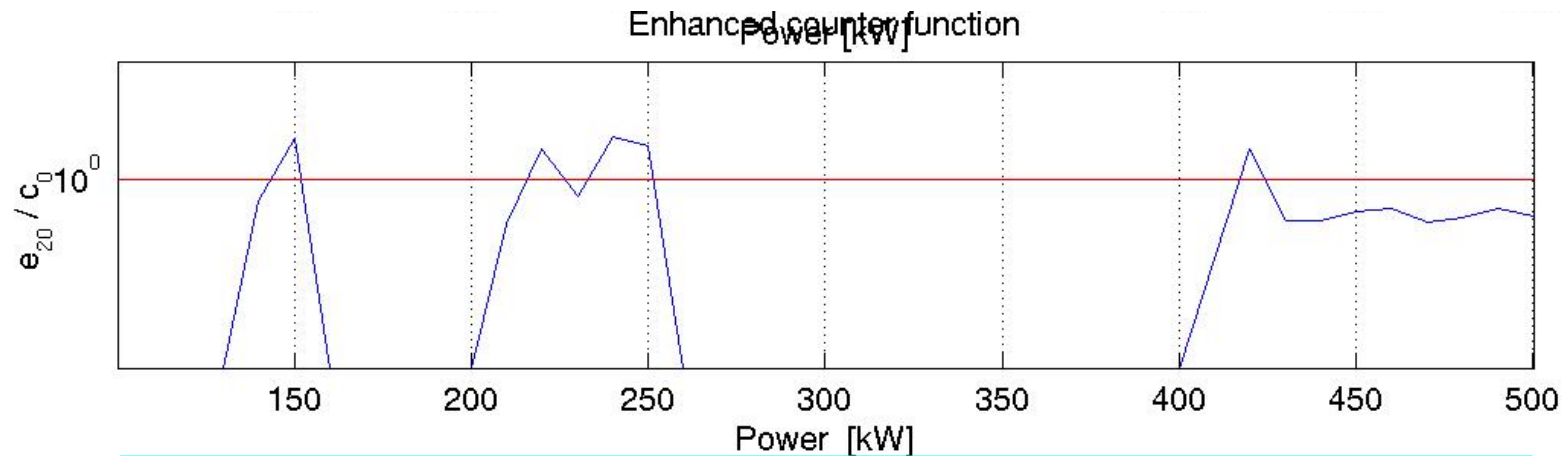
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# MultiPac (5)

Cold side cold window MP



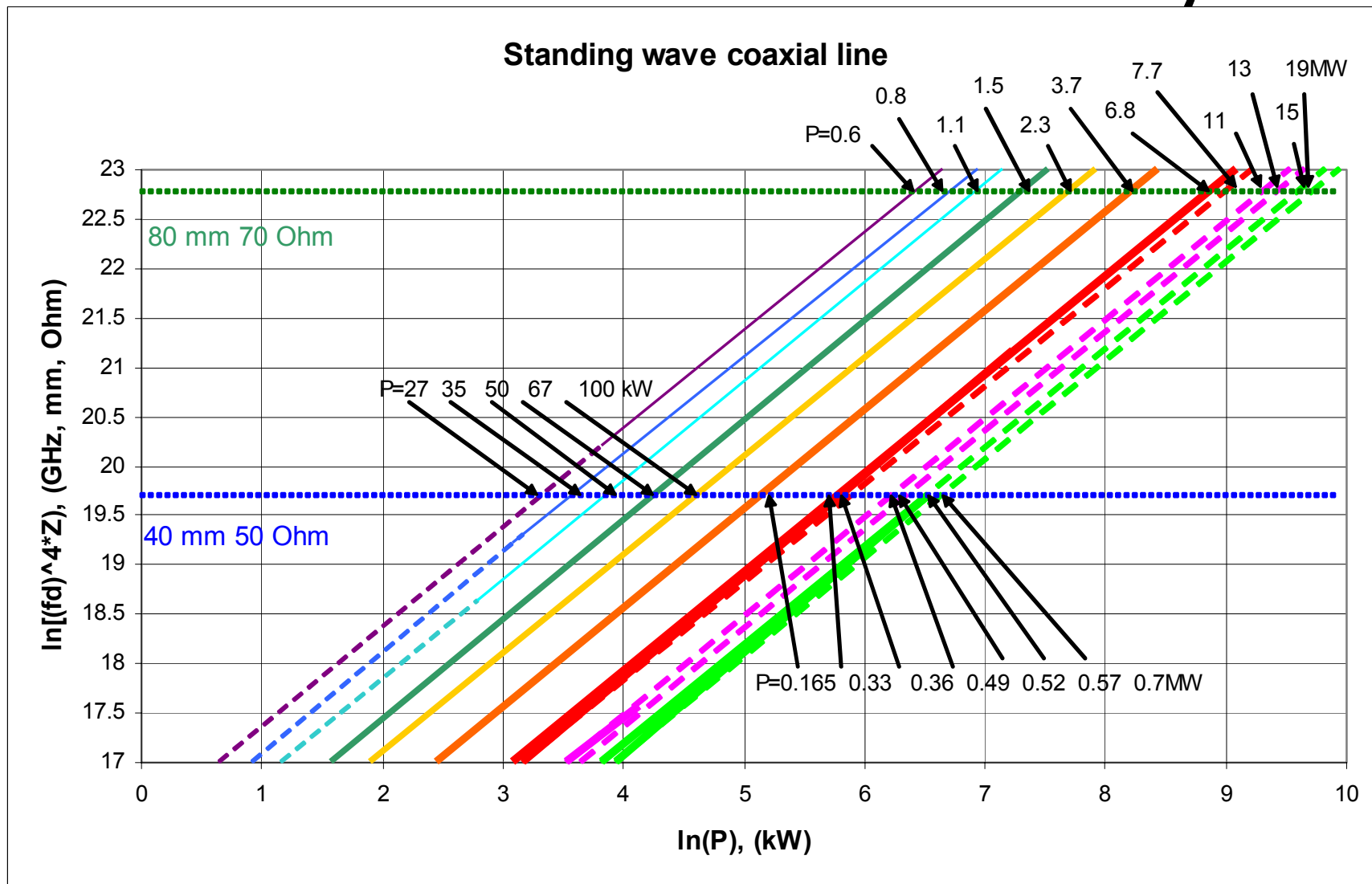
MP levels: 410-420kW, 575-620kW and 825-970kW



MP levels: 145-152kW, 220-225kW, 230-250kW, 420-425kW

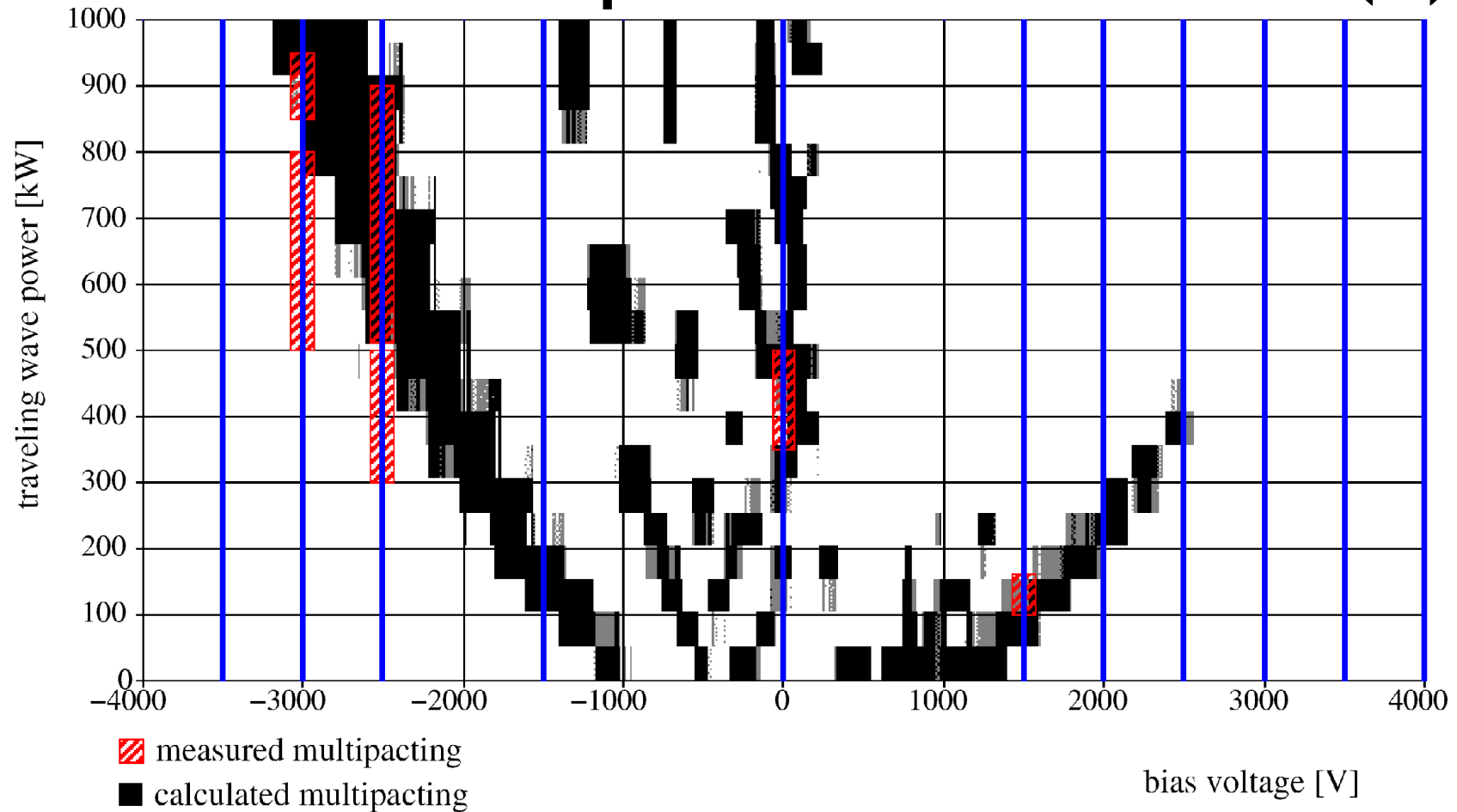
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# Calculations: Analytical



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### 3. Experimental results (1)

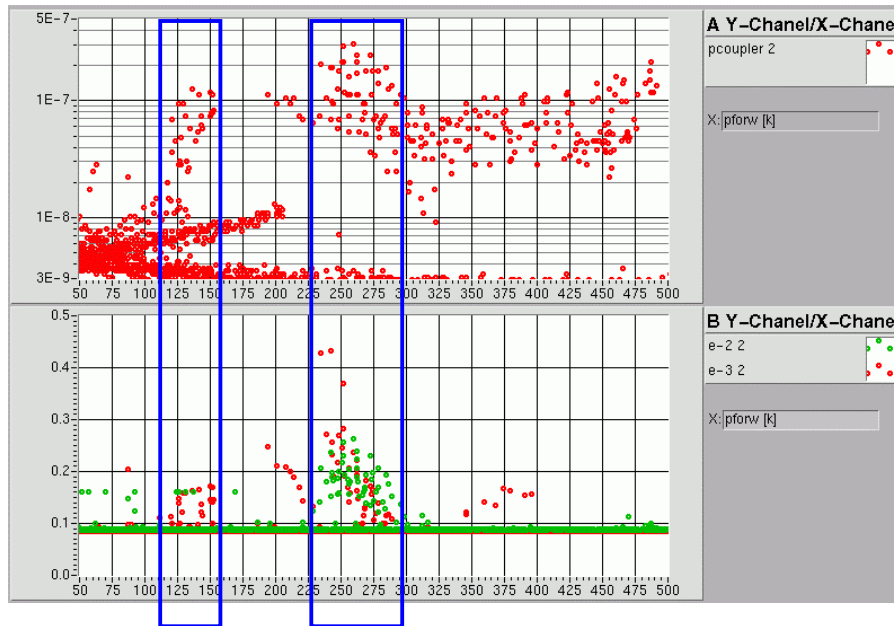


The plot of the calculated multipacting bands in a coaxial line ( $d = 62$  mm,  $Z = 50$  Ohm) as a function of the incident power (vertical axis) and the DC biasing voltage (horizontal axis). The red areas are the measured activities (e- pick up) in the warm coax of the TTF II coupler

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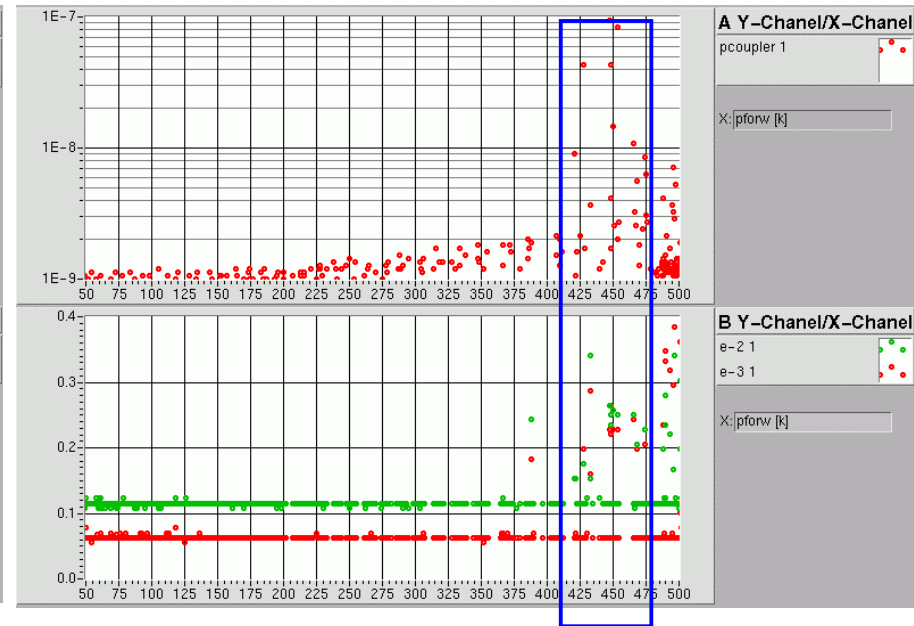
# Experimental results (2)

## TTF III coupler test: coupler test stand (TW)



D3C19/20

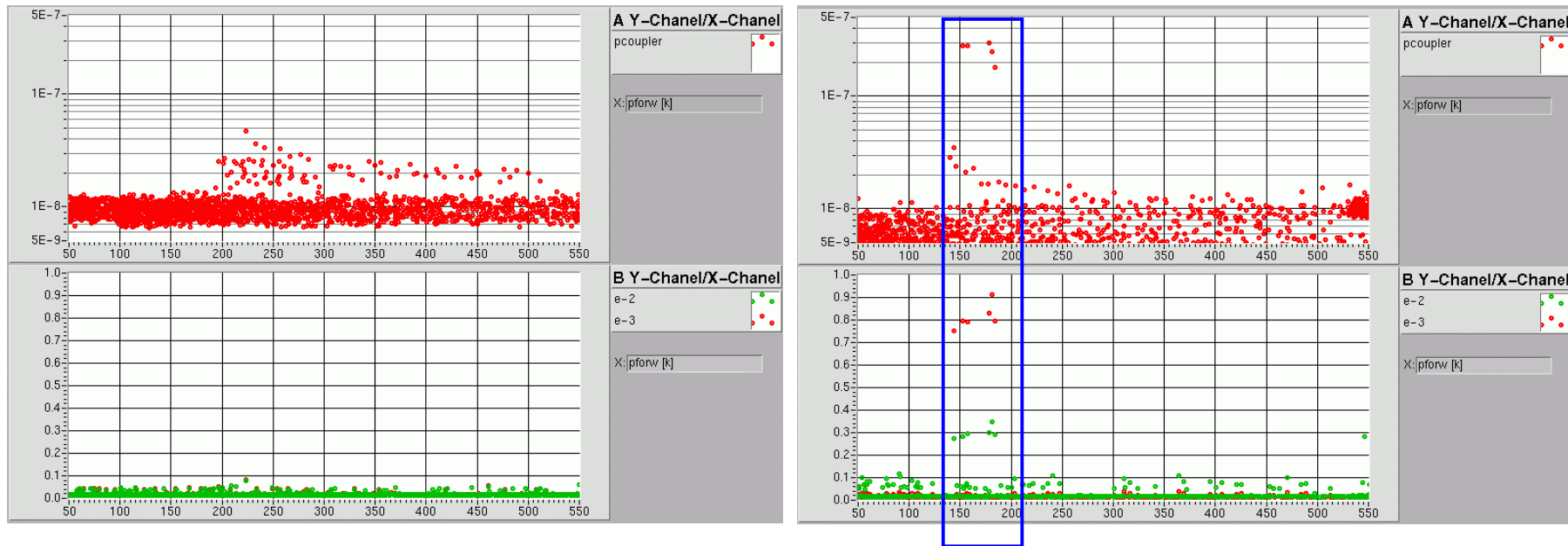
1.3ms power sweep



D3C3/4

# Experimental results (3)

## TTF III coupler test: horizontal cavity test stand (SW)



D3C3 (baked)

1.3ms power sweep

D3C3 (not baked)

## 4. Summary

1. Developed MP calculation tools (MultiPac) allows MP levels determinations at coupler design stage.
2. TTF III coupler tests: MP levels found around 150kW, 250kW, 450kW in the warm coupler part, 150 and 450kW in the cold coupler part (not in the all tests). Calculations also show MP near to this power levels. Those levels are not dangerous.
3. Applying the high voltage (HV) between inner and outer coax parts of negative value down to  $-3.5\text{kV}$  caused lots of activity and general deterioration of coupler performance, while positive values of HV up to  $+3.5\text{kV}$  made almost no difference to no HV at all, just shifting of the multipacting levels as it must be. So, as a conclusion, we don't need HV to operate the coupler.
4. It is clear, that TiN coating of the ceramic windows dramatically reduces MP in TTF III coupler.